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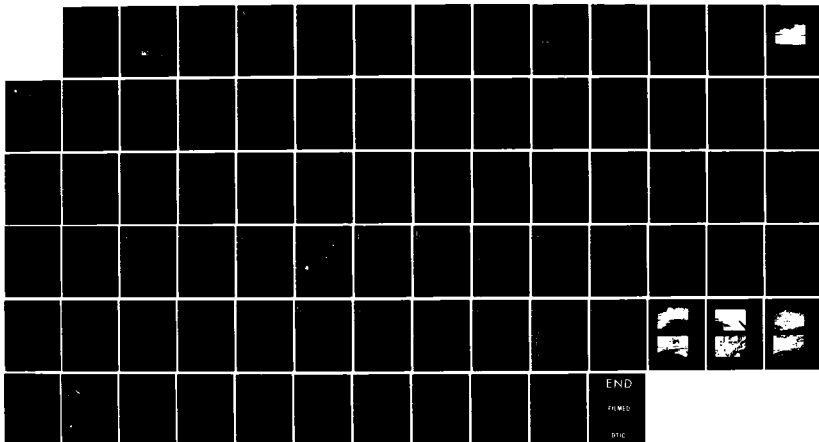
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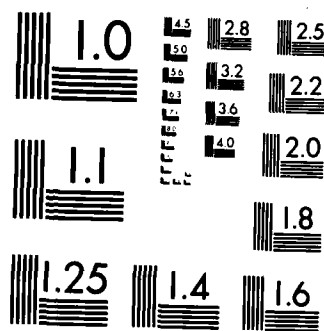
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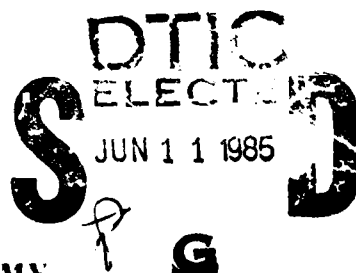
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MERRIMACK RIVER BASIN
MARLBOROUGH, MASSACHUSETTS

FORT MEADOW RESERVOIR DAM
MA 00449

**PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM**

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02134

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OCTOBER 1978

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) DAMS, INSPECTION, DAM SAFETY, Merrimack River Basin Marlborough, Massachusetts Fort Meadow Brook - Tributary of Assabet River		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) There are two inbounding structures at Fort Meadow Reservoir- and earthfill dam and an earth dike adjacent to a spillway with a concrete weir. The dam is about 320 ft. long and 30 ft. high. The dike is about 80 ft. wide and 3.5 ft. high, and the spillway is 13.3 ft. long. The dam is considered to be in generally poor condition. It also has a high hazard potential level.		



DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02154

REPLY TO
ATTENTION OF:

SEP 24 1979

NEDED-E

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts

Dear Governor King:

Inclosed is a copy of the Fort Meadow Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. The report is based upon a visual inspection, a review of past performance, and a preliminary hydrological analysis. A brief assessment is included at the beginning of the report.

The visual inspection has revealed that the earthen dike north of the spillway is approximately 2 feet lower in elevation than the main dam. In addition the preliminary hydrologic analysis has indicated that the spillway capacity for the Fort Meadow Reservoir Dam would likely be exceeded by floods greater than 1.2 percent of the Probable Maximum Flood (PMF), the test flood for spillway adequacy. Our screening criteria specifies that a dam of this class which does not have sufficient spillway capacity to discharge fifty percent of the PMF, should be adjudged as having a seriously inadequate spillway and the dam assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The term "unsafe" applied to a dam because of an inadequate spillway does not indicate the same degree of emergency as that term would if applied because of structural deficiency. It does indicate, however, that a severe storm may cause overtopping and possible failure of the dam, with significant damage and potential loss of life downstream.

It is recommended that within twelve months from the date of this report the owner of the dam engage the services of a professional or consulting engineer to determine the feasibility of raising the dike to an elevation equal to that of the main dam and to determine by more sophisticated methods and procedures the magnitude of the spillway deficiency. Based on this determination, appropriate remedial mitigating measures should be designed and completed within 24 months of this date of notification. In the interim a detailed emergency operation plan and warning system should be promptly developed. During periods of unusually heavy precipitation, round-the-clock surveillance should be provided.

NEDED-E

Honorable Edward J. King

I have approved the report and support the findings and recommendations described in Section 7, with qualifications as noted above. I request that you keep me informed of the actions taken to implement these recommendations since this follow-up is an important part of the non-Federal Dam Inspection Program.

A copy of this report has been forwarded to the Department of Environmental Quality Engineering, the cooperating agency for the Commonwealth of Massachusetts. This report has also been furnished to the owner of the project, City of Marlborough, Department of Public Works.

Copies of this report will be made available to the public, upon request to this office, under the Freedom of Information Act, thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for the cooperation extended in carrying out this program.

Sincerely,

M. B. Scheider

MAX B. SCHEIDER
Colonel, Corps of Engineers
Division Engineer

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FORT MEADOW RESERVOIR DAM

MA 00449

MERRIMACK RIVER BASIN
MARLBOROUGH, MASSACHUSETTS

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION
PROGRAM

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

BRIEF ASSESSMENT

Identification No.: MA00449

Name of Dam: Fort Meadow Reservoir

Town: Marlborough

County and State: Middlesex County, Massachusetts

Stream: Fort Meadow Brook - Tributary of Assabet River

Date of Inspection: September 5, 1978

There are two impounding structures at Fort Meadow Reservoir - an earthfill dam with a gated outlet, and an earth dike adjacent to a spillway with a concrete weir. The dam was originally constructed in 1848, but was entirely reconstructed in 1871, and underwent major repairs in 1963. The dam is about 320 feet long and 30 feet high. The outlet is a 20-inch diameter pipe that discharges from a concrete conduit outfall. The dike is about 80 feet wide and 3.5 feet high, and the spillway is 13.3 feet long.

Fort Meadow Reservoir Dam was neither designed nor constructed by current approved, state-of-the-art procedures. However, major repairs were performed on the dam in 1963 which were designed by Metcalf & Eddy, Inc. Based upon the visual inspection at the site and a review of the limited engineering data available, there are areas of concern which must be corrected to assure the continued performance of this dam. Generally, the dam is considered to be in poor condition. There are several visible signs of distress which may indicate a potential hazard at this site. These are as follows: severe seepage at the north abutment, erosion on the crest and upstream face of the dam, difficult access to the gate mechanism in the gate chamber, leakage around the gate, erosion of the downstream slope, heavy accumulation of trees and brush on the dam, displacement of the concrete slab at the spillway, and accumulation of wood and debris in the spillway channel.

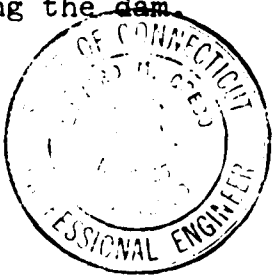
FORT MEADOW RESERVOIR DAM

Hydraulic analyses indicate that the existing spillway can discharge a flow of 41 cubic feet per second (cfs) at Elevation (El) 263 which is the low point of the top of the dike. An outflow test flood of 3,400 cfs would overtop the low dike by about 3.4 feet and the main dam by about 1.4 feet. The small spillway can only discharge 1.2 percent of the test flood before the low dike is overtopped. If the dike is overtopped and does not fail, then about 25 percent of the test flood can be passed before the main dam is overtopped.

In the event of dam failure, a hazard exists for residents in the immediate area due to the anticipated height of the flood wave. For this reason, the dam has been classified in the "high" hazard category.

Because of this potential hazard, it is recommended that the Owner employ a qualified consultant to investigate the severe seepage at the north abutment and to design an adequate spillway. In addition, the Owner should repair the spillway and the outlet gate and install a mechanical operator at the top of the gate chamber. Also, it is recommended that the Owner repair the erosion on the crest, replace the riprap, and remove all trees, brush, and debris from the dam, dike, and spillway channel. The Owner should also implement a systematic program of inspection and maintenance.

The recommendations and remedial measures described in Section 7 should be implemented by the Owner within a period of 1 year after receipt of this Phase I Inspection Report. An alternative to these recommendations would be draining the reservoir and breaching or removing the dam.



Edward M. Greco

Edward M. Greco, P.E.
Project Manager
Metcalf & Eddy, Inc.

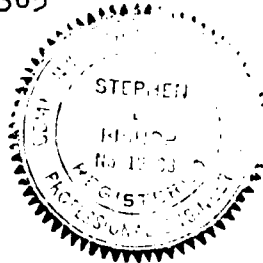
Connecticut Registration
No. 08365

Approved by:

Stephen L. Bishop

Stephen L. Bishop, P.E.
Vice President
Metcalf & Eddy, Inc.

Massachusetts Registration
No. 19703



FORT MEADOW RESERVOIR DAM

This Phase I Inspection Report on Fort Meadow Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Charles G. Tiersch

CHARLES G. TIERSCH, Chairman
Chief, Foundation and Materials Branch
Engineering Division

Fred J. Ravens, Jr.

FRED J. RAVENS, Jr., Member
Chief, Design Branch
Engineering Division

Saul Cooper

SAUL COOPER, Member
Chief, Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

PREFACE

This report is prepared under guidance contained in Recommended Guidelines for Safety Inspection of Dams, for a Phase I Investigation. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detail investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

FORT MEADOW RESERVOIR DAM

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FORT MEADOW RESERVOIR DAM

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**OVERVIEW
FORT MEADOW RESERVOIR
MARLBOROUGH, MASSACHUSETTS**



VIEW FROM UPSTREAM OF SOUTH ABUTMENT

**Location and Direction of Photographs
Shown on Figure in Appendix B**

headwall. The concrete is in fair condition. The channel downstream of the culvert is clear of brush and looks freshly excavated. There is some erosion next to the headwall and down the sides of the channel. The inside of the pipe is partially filled with soil and rock.

- d. Reservoir Area. There are many seasonal and year-round homes situated on the shore of Fort Meadow Reservoir. The most densely populated areas are the subdivisions south and east of the dam; and north of the reservoir near the Hudson-Marlboro boundary. There are lakefront vacation homes along Red Spring Road on the south side of the Reservoir. At the time of the inspection there was less than 2 feet of freeboard along this shore road. It is likely that parts of this road would be impassable during periods of high water.

There are two other low spots noted along the reservoir. One is at the south abutment of the dam, and runs perpendicular to the reservoir to Hosmer Street. It is a grass-covered, natural swale situated between the driveway of a lake-front home and the City of Marlborough property on the reservoir. A chain-link fence stands parallel to the axis of the swale, in the trough. The swale is about 70 feet wide and 4 feet deep. The lowest point is at El 263.8, only 1.8 feet above the crest of the spillway. In the event of flooding, the swale could serve as an auxiliary spillway to draw some of the overflow out of the reservoir and relieve some of the pressure on the dam.

A second apparent low spot was investigated on Lake Shore Drive between the dam and the dike. Elevations taken at this location showed that the road was at least 3 feet above the dam.

The west end of Fort Meadow Reservoir is relatively undeveloped, as there are no roads along the pond at that end. Also, the reservoir is artificially divided by Route 85 and Marlboro Street in this area.

FORT MEADOW RESERVOIR DAM

The outlet works are only accessible through the manhole situated at the upper end of the downstream slope. The gate is opened every two years, and at the time of the inspection the cover was hidden by soil, leaves, and debris. The manhole was probed to 21 feet, but was flooded with 11 feet of water. According to the Marlborough DPW, when the manhole is flooded, the outlet gate must be opened from the surface by using a wrench on an extension pole. At the time of the inspection, the gate was closed. However, water was observed flowing from the outfall at a rate of approximately 50 gallons per minute.

The dike adjacent to the spillway is very low and not easily distinguished from the rest of the shoreline. The dike ties into natural ground at the west abutment, and ends in a curb wall at the spillway. The east side of the spillway is natural ground and private property. The crest and shoreline of the dike are irregular, eroded, and riddled with animal burrows and tree roots. Several trees are growing at the water line, and at the downstream toe. There is no riprap protection. The dike is only about one foot higher than the crest of the spillway.

The spillway is in poor condition. The inlet section of the concrete slab is displaced, and the concrete on the downstream slope is cracked and crumbling. At the time of the inspection, there was no water flowing over the weir, but slight seepage was noted discharging from under the slab.

The floor of the spillway channel is naturally paved with cobbles and boulders, and there are many overhanging trees. Two footbridges and a small length of snow fencing are strung across the channel.

The channel passes under a private road about 320 feet downstream of the reservoir. The culvert is a 54-inch diameter reinforced concrete pipe in a stone and concrete reinforced

SECTION 3
VISUAL INSPECTION

3.1 Findings

- a. General. The Phase I inspection of the dam at Fort Meadow Reservoir was performed on September 5, 1978. A copy of the inspection checklist is included in Appendix A. Earlier inspection reports by the Middlesex County Commissioners, Metcalf & Eddy, and the Massachusetts Department of Public Works are all included in Appendix B.
- b. Dam. The main earth embankment is in poor condition. The major problem is the amount of seepage through the north abutment, where the dam ties into a hill. The downstream slope of the natural abutment is locally damp and soft. At the time of the inspection, water was seeping from the toe of the hill on both sides of the footpath. Since most of this water appeared to originate below the bath house, the seepage may indicate a leaking water or sewer line. However, simple dye test conducted during the inspection did not substantiate this.

The seepage areas and the rest of the downstream face of the dam are entirely overgrown by trees and brush. This made the inspection particularly difficult, as the overgrowth could be hiding other serious problems.

Trespassing on the downstream slope of the dam has eroded a footpath through the vegetation. There are also eroded areas on the crest and along the shoreline.

- c. Appurtenant Structures. The intake and conduit for the outlet are not visible. The concrete on the conduit outfall is in good condition, with only minor surface honeycombs. The outlet to the pipe is completely hidden by weeds growing between the wingwalls of the structure.

FORT MEADOW RESERVOIR DAM

- b. Adequacy. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of reviewing design and construction data, but is based primarily on visual inspection, past performance history and sound engineering judgment.
- c. Validity. Comparison of the available drawing with the field survey conducted during the Phase I inspection indicates that the information is valid.

FORT MEADOW RESERVOIR DAM

SECTION 2
ENGINEERING DATA

- 2.1 General. There are no plans, specifications or computations available from the Owner or State or County offices relative to the original design or construction of this dam. A 1963 plan by Metcalf & Eddy titled "Installation of Toe Drains" shows details of repair work completed on the dam and outlet, but gives no additional information on the construction of the embankment. A copy of this plan is included in Appendix B.

We acknowledge the assistance and cooperation of personnel of the Massachusetts Department of Public Works, Messrs. Willis Regan and Raymond Rochford, and of the Massachusetts Department of Environmental Quality Engineering, Division of Waterways, Messrs. John J. Hannon and Joseph Iagallo.

The Middlesex County Commissioners office was contacted for additional information, but their records are now filed with the State Division of Waterways.

Mr. Francis Zanca, Assistant Commissioner, and Mr. John Hartley, both of the Marlborough Department of Public Works, provided valuable information on the history of the dam, and on operating and maintenance procedures.

- 2.2 Construction Record. The only construction record is the 1963 plan on toe drain installation. There are no as-built drawings for the dam.
- 2.3 Operating Records. No operation records are available, and there is no daily record kept of the elevation of the water level in the reservoir or rainfall at the dam site.
- 2.4 Evaluation
- a. Availability There is limited engineering data available due to the age of the dam.

FORT MEADOW RESERVOIR DAM

- (2) Length: 325 feet
- (3) Height: 30 feet
- (4) Top width: Varies 23 to 45 feet
- (5) Side slopes: Upstream - 8:1
Downstream - 2:1
- (6) Zoning: Unknown
- (7) Impervious core: Unknown
- (8) Cutoff: Unknown
- (9) Grout curtain: Unknown

1. Spillway

- (1) Type: Broad crest
- (2) Length of weir: 13.3 feet
- (3) Crest elevation: 262.0 MSL (assumed benchmark)
- (4) Gates: None
- (5) Upstream channel: None
- (6) Downstream channel: Concrete weir to 6-foot wide earth channel. Channel empties into Fort Meadow Brook about 1,000 feet downstream.
- (7) General: Spillway is adjacent to earth dike. Dike is 80 feet long and 3.5 feet high. Crest elevation ranges from 263.0 to 263.7.

- j. Regulating Outlets. The only regulating outlet is the gate valve at the outlet conduit. The gate operating mechanism is accessible through a manhole on the downstream face of the dam, at El 257.9. The manhole is presently filled with water to El 247.9.

FORT MEADOW RESERVOIR DAM

(8) Stream bed at outfall of dam: 237.3

(9) Maximum tailwater: 237.1

d. Reservoir

(1) Length of maximum pool: 9,000 feet

(2) Length of recreation pool: 9,000 feet

(3) Length of flood control pool: N/A

e. Storage (acre-feet)

(1) Test flood surcharge: 1,170 at El 266.4

(2) Top of dam: 4,800

(3) Flood control pool: N/A

(4) Recreation pool: 4,000 (Approximate)

(5) Spillway crest: 4,000

f. Reservoir Surface (acres)

*(1) Top dam: 265

*(2) Test flood pool: 265

(3) Flood-control pool: N/A

(4) Recreation pool: 265

(5) Spillway crest: 265

g. Dam

(1) Type: Earthfill

*Based on the assumption that the surface area will not significantly increase with changes in pond elevation from 262 to 265.

FORT MEADOW RESERVOIR DAM

a narrow valley between Gospel Hill and Whitney Hill, flows through a culvert under Main Street, and enters a swamp. Six-tenths of a mile below Main Street, the brook flows into the Assabet River.

Hydraulic analyses indicate that the spillway can discharge an estimated 41 cfs at water surface El 263.0, which is equivalent to the crest elevation of the dike. An outflow test flood of 3,400 cfs will overtop the dam by a maximum 1.4 feet and the dike by approximately 3.4 feet.

Controlled discharge is through the gated outlet at the dam. When the gate is opened, water is conducted by the 20-inch cast-iron pipe to the conduit outfall situated at the toe of the dam near the north abutment. The discharged water enters a pool that is also fed by surface drainage from nearby Spoon Hill. Water leaving the pool flows north in a man-made channel until it also reaches Fort Meadow Brook, about 1,000 feet downstream.

- c. Elevation (feet above Mean Sea Level (MSL)). A benchmark was established at El 262.0 at the crest of the spillway. This elevation was estimated from a United States Geological Survey (U.S.G.S.) topographic map.

- (1) Top dam: 265.0 to 265.7
- (2) Test flood pool: 266.4
- (3) Design surcharge (original design):
Unknown
- (4) Full flood control pool: Not Applicable
(N/A)
- (5) Recreation pool: 262.0
- (6) Spillway crest (ungated): 262.0
- (7) Upstream portal invert diversion tunnel:
N/A

FORT MEADOW RESERVOIR DAM

There is no record of any further construction at the dam following the 1963 repair work.

1. Normal Operating Procedure. The Department of Public Works opens the outlet gate every 2 years and lowers the water level 5 to 6 feet. The purpose is to allow residents the opportunity to clean up their waterfront property. The gate was last opened in September 1977.

1.3 Pertinent Data

- a. Drainage Area. Fort Meadow Reservoir has a drainage area of approximately 2,200 acres (3.44 square miles). The natural drainage is altered somewhat in the southwest by Route 495 (see Location Map). The highway embankment serves as an artificial divide in the Flagg Swamp area, south of Interchange 13.

Sheep Fall Brook and Flagg Brook join about one-half mile upstream of the reservoir. Both drain into Fort Meadow from the west. Most of the watershed is sparsely developed, glacial terrain of hills and swamps. The most densely populated sections are to the south, within the City of Marlborough proper; and east, in the subdivisions off Stevens and Hosmer Street. In Hudson, the most highly developed section of the drainage area is on the south slope of Round Top Hill, adjacent to the reservoir. The Boston and Maine Railroad and Route 85 both cross the watershed from northwest to southeast.

- b. Discharge at the Dam Site. Water is discharged uncontrolled over the 13.3-foot long spillway (El 262.0) and into an earth channel. From its widest point, at the spillway crest, the channel narrows to 6 feet, and slopes at about one percent. Water flows through a 54-inch diameter reinforced concrete pipe (invert El 250.7) under Lake Shore Drive and then to Causeway Street, where it joins Fort Meadow Brook. The brook continues for 1-1/2 miles in

and inspect the dam was granted by Mr. Francis Zanca, Assistant Commissioner of the Department of Public Works, Municipal Garage, Neil Street, Marlborough, Massachusetts (Telephone 617-485-0392).

- f. Operator. The Department of Public Works of the City of Marlborough operates the dam.
- g. Purpose of the Dam. The dam was originally built as a storage reservoir for mill operations. The last private owner was the Maynard Woolen Works, who sold the property to the City of Marlborough. The reservoir is currently used for recreation.
- h. Design and Construction History. According to a report by the Middlesex County Commissioners, the dam was originally constructed in 1848, and essentially rebuilt in 1871 after it failed. There are no construction records available for the period between 1848 and 1963. In 1963, the embankment of the dam was rated in poor condition by engineers retained by the Middlesex County Commissioners Office. As the result of an inspection report by Metcalf & Eddy, Inc. to the County (copy in Appendix B), the Commissioners ordered the City to lower the reservoir and proceed with the necessary repairs to the dam. A 1963 drawing entitled "Toe Drain Installation" (also in Appendix B) shows the essential repair work. To prevent piping through the embankment, a toe drain was constructed consisting of a sand filter overlain by layers of stone with a rock cover. In addition, the existing 20-inch diameter cast-iron conduit was extended, and a 15-foot long concrete conduit outfall constructed. The purpose was to carry the discharge away from the toe and thereby prevent further erosion of the embankment. Impervious compacted fill was added to each abutment on the downstream slope to repair the erosion to the embankment. Finally, a French drain was installed at the toe of the north abutment to collect seepage from that area. It was also recommended that the spillway be enlarged, however, this recommendation was not implemented.

FORT MEADOW RESERVOIR DAM

inlet to the pipe is submerged. The outlet conduit passes through the embankment and discharges into a concrete conduit outfall located at the downstream toe of the dam. The invert of the outlet is at El 237.3. The gate chamber is a manhole located on the downstream face of the embankment, about 12 feet down the slope. The chamber, which was probed to El 236.8 (21.1 feet deep), was flooded with water, making the gate valve inaccessible.

The spillway is located about 1,000 feet north of the dam, adjacent to a low earth dike. It is a flat, broad-crested weir constructed of 8-inch high concrete curb walls and a concrete crest. The spillway, which is 13.3 feet long, is at El 262.0. Discharge is over the crest and an earth channel that eventually flows into Fort Meadow Brook.

The dike is approximately 80 feet long and 3.5 feet high. At El 263.0, the crest is only one foot higher than the crest of the spillway. The dike ties into natural ground at the west abutment, and the curb wall to the spillway at the east abutment. The downstream side slopes into woodland.

- c. Size Classification. Fort Meadow Reservoir Dam is classified in the "intermediate" category because it has a maximum height of 30 feet and a maximum storage capacity of approximately 4,800 acre-feet.
- d. Hazard Classification. The dam is located on the edge of a highly developed residential area of Marlborough. Were the dam to fail, the resulting flood wave could jeopardize the lives and property of residents in the Hosmer Street-Miles Standish Drive area. The flood wave would eventually be channelled into the valley of Fort Meadow Brook, but because of the immediate danger to adjacent homes, the dam is placed in the "high" hazard category.
- e. Ownership. The dam is owned by the City of Marlborough. Permission to enter the property

FORT MEADOW RESERVOIR DAM

1.2 Description of Project

- a. Location. The dam is located in the City of Marlborough, Middlesex County, Massachusetts, on Fort Meadow Brook, a tributary of the Assabet River (see Location Map).
- b. Description of Dam and Appurtenances. Fort Meadow Reservoir and Dam are used for recreation by the City of Marlborough. There are picnic tables and barbeque grills on the crest of the dam, and a sandy beach and bath house on the hill adjacent to the north abutment. An asphalt walkway leads from the boat house, down the face of the north abutment, to a paved parking lot below. During the off-season access to the dam and beach is prevented by a locked gate on the chain-link fence along the crest of the dam. However, there is now a hole in the fence near the north abutment and a second footpath has been created by trespassers.

The dam is an earthfill structure approximately 325 feet long and 30 feet high (see Appendix B, Figures B-1, B-2, and B-4). The tree-lined crest is generally 23 to 45 feet wide, but wider at the abutment areas. The crest of the dam varies slightly from El 265 to El 265.5. The sandy upstream face of the dam slopes very gently into the reservoir; there is about 3 feet of freeboard for the dam.

The downstream face slopes at about 2:1 (horizontal to vertical) and is heavily overgrown with trees and brush. In order to prevent piping through the dam, a toe drain, which was designed by Metcalf & Eddy, Inc. in May 1963, was installed on the embankment. The toe drain consisted of a sand filter overlain by layers of stone and finally 12-inch boulders. Seepage through the dam collects in the swampy area below the embankment and then flows into Fort Meadow Brook (see Figure B-1).

The outlet is located at the dam and consists of a 20-inch diameter cast-iron pipe. The

NATIONAL DAM INSPECTION
PROGRAM

PHASE I INSPECTION REPORT

FORT MEADOW RESERVOIR

SECTION 1

PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Metcalf & Eddy, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed was issued to Metcalf & Eddy, Inc. under a letter of July 28, 1978, from Ralph T. Garver, Colonel, Corps of Engineers. Contract No. DACW 33-78-C-0306 has been assigned by the Corps of Engineers for this work.

b. Purposes

- (1) Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.
- (2) Encourage and assist the States to initiate quickly effective dam safety programs for non-Federal dams.
- (3) Update, verify and complete the National Inventory of Dams.

FORT MEADOW RESERVOIR DAM



LOCATION MAP OF DAM, DIKE AND SPILLWAY

e. Downstream Channel. The discharge from the outlet flows into a small grassy pool which is separated from the main road by a large public parking lot. Water from the pool flows under the footpath in a double culvert of corrugated metal pipe, and eventually into Fort Meadow Brook. Discharge from the spillway flows in an earth channel and also joins Fort Meadow Brook about 1,000 feet downstream.

3.2 Evaluation. The above findings indicate that the dam has several signs of distress which require attention. It is evident that the dam is not adequately maintained and that deterioration will continue unless action is taken. Recommended measures to improve these conditions are included in Section 7.

SECTION 4

OPERATING PROCEDURES

- 4.1 Procedures. The normal operating procedure is to open the gate every two years and lower the water level 5 or 6 feet. The purpose of this is to give the shore residents the opportunity to work on their waterfront property.
- 4.2 Maintenance of Dam. Maintenance work on the dam was last performed in conjunction with the installation of the toe drains in 1963. Since then, there has been no regular maintenance program. The Marlborough Recreation Department is responsible for clearing the beach and waterfront area for summer activities, but this does not include care of the dam itself.
- 4.3 Maintenance of Operating Facilities. The outlet at the dam is reportedly operable, and was last opened in September 1977. The leaking gate and flooding in the manhole has probably been a problem for a number of years; the operators have devised a method for opening the gate valve from the top of the manhole, without having to drain it.
- 4.4 Description of Any Warning System in Effect. There are no warning systems in effect at this dam.
- 4.5 Evaluation. The operational and maintenance systems at this dam are inadequate, and there is no warning system in effect. This is an unsatisfactory situation considering that the dam is in the "high" hazard category. A program of operation and maintenance for this dam should be implemented as recommended in Section 7.

SECTION 5

HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

- a. Design Data. The Probable Maximum Flood (PMF) rate was determined to be 1,450 cfs per square mile. This calculation is based on the average drainage area slope of 3.5 percent, the pond-plus-swamp area to drainage area ratio of 15 percent, and the U. S. Army Corps of Engineers' guide curves for Maximum Probable Flood Peak Flow Rates (dated December 1977). Applying the full PMF to the 3.44 square miles of drainage area results in a calculated peak flood flow of 5,000 cfs as the inflow test flood. By adjusting the inflow test flood for surcharge storage, the maximum discharge rate was established as 3,400 cfs (988 cfs per square mile), with a water surface at El 266.4.

Flow over the crest of the dam and dike is predicted to be 3,017 cfs. Flow through the spillway would be 383 cfs. The maximum head on the dike would be 3.4 feet with a discharge of 16.0 cfs per foot of width. Depth at critical flow would be at 2.0 feet with a velocity of 8.0 feet per second.

Hydraulic analyses indicate that the existing spillway can discharge a flow of 41 cfs with the water surface at El 263 which is the crest of the dike.

- b. Experience Data. Hydraulic records are not available for this dam. According to the Marlborough Department of Public Works, the dam was not overtopped during the 1938 or 1955 storms.
- c. Visual Observations. The small spillway is highly inadequate to pass flood discharges without overtopping. The adjacent low dike has a top elevation of only about 1 foot above spillway crest. The ability of this low dike to withstand appreciable overtopping

FORT MEADOW RESERVOIR DAM

is not known. The downstream channel is fairly shallow. Trees are growing on the banks and in the floor of the channel. There is a chain-link boundary fence on the north bank of the channel, and two smaller fences strung across the channel. The fences have a potential for collecting debris washed out during a flood and obstructing flow in the channel.

- d. Overtopping Potential. The outflow test flood of 3,400 cfs would overtop the dike by 3.4 feet, and therefore the dam by about 1.4 feet. In event of overtopping, complete failure of the dike and dam could occur.

Failure of the dam would produce a peak discharge of 25,700 cfs and a flood wave 15.5 feet high. The channel between the dam and Miles Standish Drive is too small to attenuate the initial surge wave. Thus the failure would do considerable damage to that area.

Failure of the dike would produce a peak discharge of 210 cfs and a minimal wave in the channel (about 5 feet). The effect on local residences would be minor, causing local flooding of the banks.

SECTION 6

STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

- a. Visual Observations. The evaluation of the structural stability of Fort Meadow Reservoir Dam is mainly based on the visual inspection conducted on September 5, 1978. As discussed in Section 3, Visual Inspection, there were several visible signs of distress.

It is recommended that a more detailed investigation be initiated to evaluate the severe seepage at the downstream face of the north abutment.

- b. Design and Construction Data. Discussions with the Owner, County and State personnel indicate that there is one plan but no specifications or computations relative to the design or construction of this dam. Furthermore, information on the type, shear strength, and permeability of the soil and/or rock materials of the dam embankment apparently does not exist.
- c. Operating Records. There is no evidence that instrumentation of any type was ever installed in Fort Meadow Reservoir Dam. The performance of this dam under prior loading can only be inferred from previous records and physical evidence at the site.
- d. Post-Construction Changes. The original dam at Fort Meadow was constructed in 1848, but was entirely rebuilt in 1871 after the dam failed. The only available record of post-construction changes refers to the toe drain installation and extension of the conduit. This is discussed in Section 1.2.h. Design and Construction History. There are no as-built drawings for the dam or spillway.

FORT MEADOW RESERVOIR DAM

- e. Seismic Stability. The dam is located in Seismic Zone No. 2 and in accordance with Phase I "Recommended Guidelines" does not warrant seismic analyses.

SECTION 7

ASSESSMENT, RECOMMENDATIONS, AND REMEDIAL MEASURES

7.1 Dam Assessment

- a. Condition. Built in 1871, Fort Meadow Reservoir Dam was neither designed nor constructed according to current approved state-of-the-art procedures. However, major repairs which were done to the dam in 1963 were designed by Metcalf & Eddy, Inc. Based upon the visual inspection at the site, and the incomplete engineering, operational, and maintenance data, there are areas of concern which must be corrected to assure the continued performance of the dam.

The dam is considered to be in poor condition, chiefly because of the severe seepage through the north abutment. There were other problems noted at the site: inaccessibility of the outlet works due to flooding in the manhole; leakage around the outlet gate; erosion on the downstream face of the dam; steep embankment slopes on the downstream face; erosion on the crest and on the upstream face; inadequate riprap protection on the upstream face; large diameter trees on the crest; and heavy growth of trees and brush on the downstream slope and in the outlet channel.

Conditions at the dike are unsatisfactory due to the inadequacy of the spillway, deterioration of the concrete spillway crest, and the accumulation of debris in the channel.

Hydraulic analyses indicate that the spillway can discharge a flow of 41 cfs when the water surface is at El 263, which is the elevation of the dike. An outflow test flood of 3,400 cfs will overtop the dike by 3.4 feet and the dam by 1.4 feet.

- b. Adequacy of Information. The lack of in-depth engineering data did not allow for a definitive review. Therefore the adequacy of this dam could not be assessed from the standpoint of

FORT MEADOW RESERVOIR DAM

reviewing design and construction data, but is based primarily on visual inspection, past performance history and engineering judgment.

- c. Urgency. The recommendations and remedial measures outlined below should be implemented by the Owner within one year after receipt of this Phase I Inspection Report.
- d. Need for Additional Investigation. Additional investigations to further assess the adequacy of the dam and appurtenant structures are outlined below in Section 7.2, Recommendations.

7.2 Recommendations. In view of the concerns on the continued performance of this dam, it is recommended that the Owner employ a qualified consultant to:

- a. Evaluate the severe seepage at the north abutment of the dam.
- b. Design an adequate spillway and/or facilities to discharge or store major flood runoff.

The recommendations on repairs and maintenance procedures are stated below under Section 7.3, Remedial Measures.

7.3 Remedial Measures

- a. Operating and Maintenance Procedures. The dam and appurtenant structures are not adequately maintained. It is recommended that the Owner accomplish the following:
 - (1) repair the displaced inlet section of the slab, and all cracked or spalled concrete on the spillway
 - (2) construct a gate mechanism that would be accessible from the top of the gate chamber
 - (3) repair the leaking valve in the outlet
 - (4) repair the eroded areas on the crest, the downstream face, and the shoreline
 - (5) add riprap to the upstream face of the dam and the dike

FORT MEADOW RESERVOIR DAM

- (6) clear the trees from the crest and the trees and brush from the downstream face of the dam
- (7) clear wood and trash debris, and remove the fences and footbridges from the channel downstream of the spillway
- (8) institute a definite plan for surveillance and a warning system during periods of unusually heavy rains and/or runoff
- (9) implement a systematic program of maintenance inspections. As a minimum, the inspection program should consist of a monthly inspection of the dam and appurtenances, supplemented by additional inspections during and after severe storms. All repairs and maintenance should be undertaken in accordance with all applicable State regulations.
- (10) technical inspections of this dam should be conducted on an annual basis

7.4 Alternatives. An alternative to the recommendations and remedial measures itemized above would be to drain the reservoir and breach or remove the dam.

APPENDIX A
PERIODIC INSPECTION
CHECKLIST

FORT MEADOW RESERVOIR DAM

PERIODIC INSPECTION

PARTY ORGANIZATION

PROJECT Fort Meadow Reservoir

DATE September 5, 1978

TIME 8:00 am

WEATHER 70°F - sunny

W.S. ELEV. 261.8 U.S. 237.8 D.N.S.

PARTY:

- | | |
|-------------------------|-----------|
| 1. <u>Ed Greco</u> | 6. _____ |
| 2. <u>Sue Pierce</u> | 7. _____ |
| 3. <u>Warren Diesl</u> | 8. _____ |
| 4. <u>Dave Cole</u> | 9. _____ |
| 5. <u>Lyle Branagan</u> | 10. _____ |

PROJECT FEATURE

INSPECTED BY

REMARKS

- | | | |
|-----------------------------|--------------------|--|
| 1. <u>Dam - spillway</u> | <u>E. Greco</u> | |
| 2. <u>Spillway - Outlet</u> | <u>L. Branagan</u> | |
| 3. _____ | | |
| 4. _____ | | |
| 5. _____ | | |
| 6. _____ | | |
| 7. _____ | | |
| 8. _____ | | |
| 9. _____ | | |
| 10. _____ | | |

PERIODIC INSPECTION CHECK LIST

PROJECT Fort Meadow Reservoir

DATE September 9, 1978

PROJECT FEATURE Dam

NAME E. Greco

DISCIPLINE Geotechnical

NAME _____

AREA EVALUATED	CONDITIONS
<u>DAM EMBANKMENT</u>	
Crest Elevation	varies from 265 to 265.5
Current Pool Elevation	261.8
Maximum Impoundment to Date	unknown
Surface Cracks	none visible
Pavement Condition	footpath; picnic area: benches, fireplaces, concrete slabs
Movement or Settlement of Crest	irregular crest
Lateral Movement	none visible - extensive vegetation
Vertical Alignment	relatively flat - irregular
Horizontal Alignment	relatively straight
Condition at Abutment and at Concrete Structures	north abutment: sandy beach south abutment: ties into natural ground; adjacent to road
Indications of Movement of Structural Items on Slopes	not visible - heavy growth of vegetation, many large (1' or more) diameter trees
Trespassing on Slopes	upstream face: picnic area; downstream face: footpaths; animal burrows
Sloughing or Erosion of Slopes or Abutments	minor erosion upstream small gullies downstream
Rock Slope Protection - Riprap Failures	random stones upstream face riprap at toe of downstream slope
Unusual Movement or Cracking at or near Toes	not visible due to heavy vegetation
Unusual Embankment or Downstream Seepage	seepage through toe drains along entire toe seepage in downstream slope of north abutment, and along footpath
Piping or Boils	none visible
Foundation Drainage Features	plan available - see Appendix B
Toe Drains	plan available - see Appendix B; 12-inch stone visible
Instrumentation System	none

PERIODIC INSPECTION CHECK LIST

PROJECT Fort Meadow ReservoirDATE 9-5-78PROJECT FEATURE DikeNAME E. GrecoDISCIPLINE Geotechnical

NAME _____

AREA EVALUATED	CONDITION
<u>DIKE EMBANKMENT</u>	
Crest Elevation	Varies from 263 to 263.7
Current Pool Elevation	261.8
Maximum Impoundment to Date	unknown
Surface Cracks	tree roots and animal holes
Pavement Condition	footpath
Movement or Settlement of Crest	very irregular crest
Lateral Movement	relatively straight
Vertical Alignment	flat grade
Horizontal Alignment	relatively straight
Condition at Abutment and at Concrete Structures	west: ties into natural ground east: ends at spillway
Indications of Movement of Structural Items on Slopes	none
Trespassing on Slopes	dumping (brush and leaves)
Sloughing or Erosion of Slopes or Abutments	crest and upstream slope eroded animal holes, roots
Back Slope Protection - Riprap Failures	none
Thermal Movement or Cracking at or near Toes	none visible
Thermal Embankment or Downstream Leakage	none visible
Sliding or Bulging	none
Foundation Drainage Features	none
Toe Drains	none
Instrumentation System	none

PERIODIC INSPECTION CHECK LIST

OBJECT Fort Meadow Reservoir DATE 9-8-78
 OBJECT FEATURE outlet NAME L. Branagan
 DISCIPLINE Hydraulics NAME E. Greco

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - OUTLET STRUCTURE AND OUTLET CHANNEL</u>	<u>See drawing, Appendix B</u>
<u>General Condition of Concrete</u>	<u>good - minor surface honeycombs</u>
<u>Rust or Staining</u>	<u>none visible</u>
<u>Spalling</u>	<u>none visible</u>
<u>Erosion or Cavitation</u>	<u>none visible</u>
<u>Visible Reinforcing</u>	<u>none</u>
<u>Any Seepage or Efflorescence</u>	<u>none through concrete *</u>
<u>Condition at Joints</u>	<u>good</u>
<u>Drain Holes</u>	<u>none visible</u>
<u>Channel</u>	<u>2-foot, stones and vegetation</u>
<u>Loose Rock or Trees Overhanging Channel</u>	<u>none</u>
<u>Condition of Discharge Channel</u>	<u>fair: channel ill-defined at outlet - overgrown by weeds</u>

* Flow from outlet pipe [gate closed]: $Q = 50 \text{ gpm}$ (approximate)
 Outlet submerged

Dam as built appears slightly different from plan

Energy dissipating bumper not visible

Should the dam fail the route of the flood would be along Fort Meadon Brook, the Assabet River, the Concord River, and the Merrimack River to the Atlantic Ocean. Following this route the flood wave would pass over about seven dams before reaching the Merrimack River. To make a prediction of what effect this would have on each of these dams would require a complex study beyond the scope of this report. It is possible, however, that one or more of these structures could fail, compounding the problem downstream. The Assabet River passes through developed areas. The topography of the river valley is such that the flood crest may not have an opportunity to subside before passing through these developed areas. Therefore, it is possible that these developed areas would be damaged by a flood.

Emergency Action

The water level in the pond should be lowered immediately until all noticeable flow of water through the embankment along the downstream toe of the slope ceases and the material comprising the slope in this area becomes firm.

Since piping failures occur rapidly, we recommend that a procedure be established by which persons living along the probable flood route could be quickly notified in case of failure. In connection with this, we feel that close watch should be kept on the structure until the condition stabilizes or else suitable repairs are made.

The main embankment section of the dam does not appear to be stable. "Piping" or the uncontrolled flow of water through the earth embankment is taking place along the downstream toe of the slope especially in the area around the outlet works. At any time this flow of water through the embankment could begin to carry with it the materials which comprise the embankment. Should this occur, failure of the structure could be very rapid. This is due to the fact that as material is removed from the embankment there is less resistance to the flow of water through the embankment. As the flow of water is increased, larger particle sizes could be carried by the water which in turn would further increase the flow of water.

In addition to the above, there is danger that the toe of the downstream slope of the main embankment could be eroded by a small stream flowing close to the slope.

Erosion has taken place on the upstream side of the main embankment indicating the need for additional protection.

Possible Damage Due to Failure

Fort Meadow Reservoir contains about 1.75 billion gallons of water.

Should a rapid failure of the main embankment occur, then it is felt that this water would cause considerable property damage. It is also possible that the failure could cause injury or loss of life along the path of the flood.

The spillway is a broad crested type made of concrete. It is about 13.5 ft. long and its crest is about 8 in. below the top of the abutment walls.

A 20 in. pipe passes through the main embankment. A manhole is located on the downstream slope which contains a valve for controlling the discharge through this pipe. A dry stone masonry headwall is located at the outlet of the pipe.

The discharge capacity of the spillway is about 20 cfs. The drainage area above the dam is about 3.5 square miles. The maximum flood flow as estimated from the Kinnison-Colby formula (rare floods) is about 990 cfs.

South of the main embankment there is a low section in the reservoir rim which would tend to relieve flood flows before the main embankment is overtopped.

A small stream approaching from the east runs close to the toe of the slope of the main embankment.

The top of the main embankment has fireplaces and is used as picnic grounds.

Condition

Considerable leakage was noted coming from the vicinity of the 20-in. pipe and the headwall at the main embankment. The downstream slope of the main embankment is also steeper than is considered good practice. In addition, both the main embankment and the spillway embankment have brush and trees growing on the slopes and across the top.

9. A small stream near the toe of the main embankment endangers the embankment by erosion.
10. Before the water level in the reservoir is restored to the present flow line the embankment should be reconstructed and an adequate drainage system provided along the toe to eliminate the possibility of failure by piping.
11. The spillway capacity should be made adequate to pass flood flows.
12. The downstream slope of the main embankment should be reconstructed to a flatter slope and the toe protected from erosion by the small stream.
13. The trees and large bushes growing on the slopes of both embankments should be removed and the slopes protected by an adequate growth of grass.
14. All plans for the repair and reconstruction of the embankments should first be approved by the County Commissioners and all work done should be inspected by the Commissioners.

Description

The main embankment is about 325 ft. long and has a height of about 30 ft. A smaller embankment containing a small spillway is located a few hundred feet to the north of the main embankment. This small embankment is about 100 ft. long and has a height of about 4 ft.

FORT MEADOW RESERVOIR DAM

2. Immediate action should be taken to lower the level of the water in the reservoir until piping the structure becomes stable. This may even require draining the reservoir.
3. The water level in the reservoir should be kept at the elevation indicated in No. 2 above until repairs are made.
4. A failure of this structure could cause considerable property damage and loss of life.
5. A warning procedure should be established to give persons in the flood path maximum notice in case of failure of the structure.
6. The drainage area to the reservoir is about 35 square miles and flood flow is estimated at around 990 cfs.* We estimate a depth of flow over the spillway crest of about 8 in. before adjacent embankments are overtopped. The capacity of the spillway is around 20 cfs. A low section in the rim of the reservoir basin south of the main embankment is at such an elevation as to provide a measure of relief before the main embankment would be overtopped.
7. The downstream slope of the main embankment is steeper, in most places, than is normally considered safe.
3. The upstream slope of the main embankment is inadequately protected from erosion.

*cubic feet per second.

METCALF & EDDY
Engineers
Boston, Massachusetts

W-1

J - 5046 REC Dam
JMK:slg
4/25/63

REPORT
UPON
FORT MEADOW RESERVOIR DAM
MARLBOROUGH-HUDSON, MASSACHUSETTS

General

The Fort Meadow Reservoir is primarily located in Marlborough, Massachusetts. The water is impounded by two earth embankments located at the easterly end of the Reservoir on the boundary between Marlborough and Hudson, Massachusetts.

According to a report by the Middlesex County Commissioners in March 1914 the dam was constructed in 1843 and extensively repaired in 1871 after a failure of the structure. The dam was originally built as a storage reservoir for mill operations but is presently used for recreational purposes and for water supply for mills downstream.

The dam is presently owned and controlled by the City of Marlborough.

Conclusions and Recommendations

1. The structure is in serious danger of failure by "piping" along the toe of the slope especially in the vicinity of the 20 in. outlet pipe.

April 23, 1963

Honorable Kuson J. Haddad
Mayor, City of Marlborough
City Hall
Marlborough, Massachusetts

Dear Mayor Haddad:

The County Commissioners call
to your urgent attention enclosed copy of report
just received from Metcalf & Eddy on the condition
of the Fort Meadow Reservoir Dam (County Dam No. W-1),
in Marlborough.

Very truly yours,

Chairman

Middlesex County Commissioners

FORT MEADOW RESERVOIR DAM

TOWN: Marlborough DAM NO. W-1

LOCATION Marlborough-Hudson Boundary STREAM Port Meadow Brook

MIDDLESEX COUNTY ENGINEERING DEPARTMENT
CAMBRIDGE, MASSACHUSETTS

DAM INSPECTION REPORT

Owned by City of Marlborough Place Marlborough Use Mill Storage Recreation

Inspected by Joseph S. Krzywicki Date 12 April 1963

Type of Dam Earth Fill Condition Poor

SPILLWAY Length 13.5 ft. Ht. to Top Emb. Section 8 inches

Flashboards in Place None Ht. of Recent Repairs None visible

Condition Fair

Repairs Needed Remove brush and trees growing adjacent to spillway.

EMBANKMENT Main - + 325 ft. Spillway - + 30 ft.
Length 100 ft. Height Spillway + 4 ft. Type Earth

Recent Repairs None noted.

Condition Main embankment - Poor - Spillway embankment - Fair

Repairs Needed Main embankment - see special remarks.

Spillway embankment - remove trees and brush, loam and grass.

GATES Number 1 Size 20 inch Type Gate valve.

Recent Repairs None

Condition Unknown

Repairs Needed Unknown

LEAKS Detailed Description and Location on Back of Sheet

How Serious very dangerous

DATE 12 April 1963

Joseph S. Krzywicki
Signature Inspecting Engineer

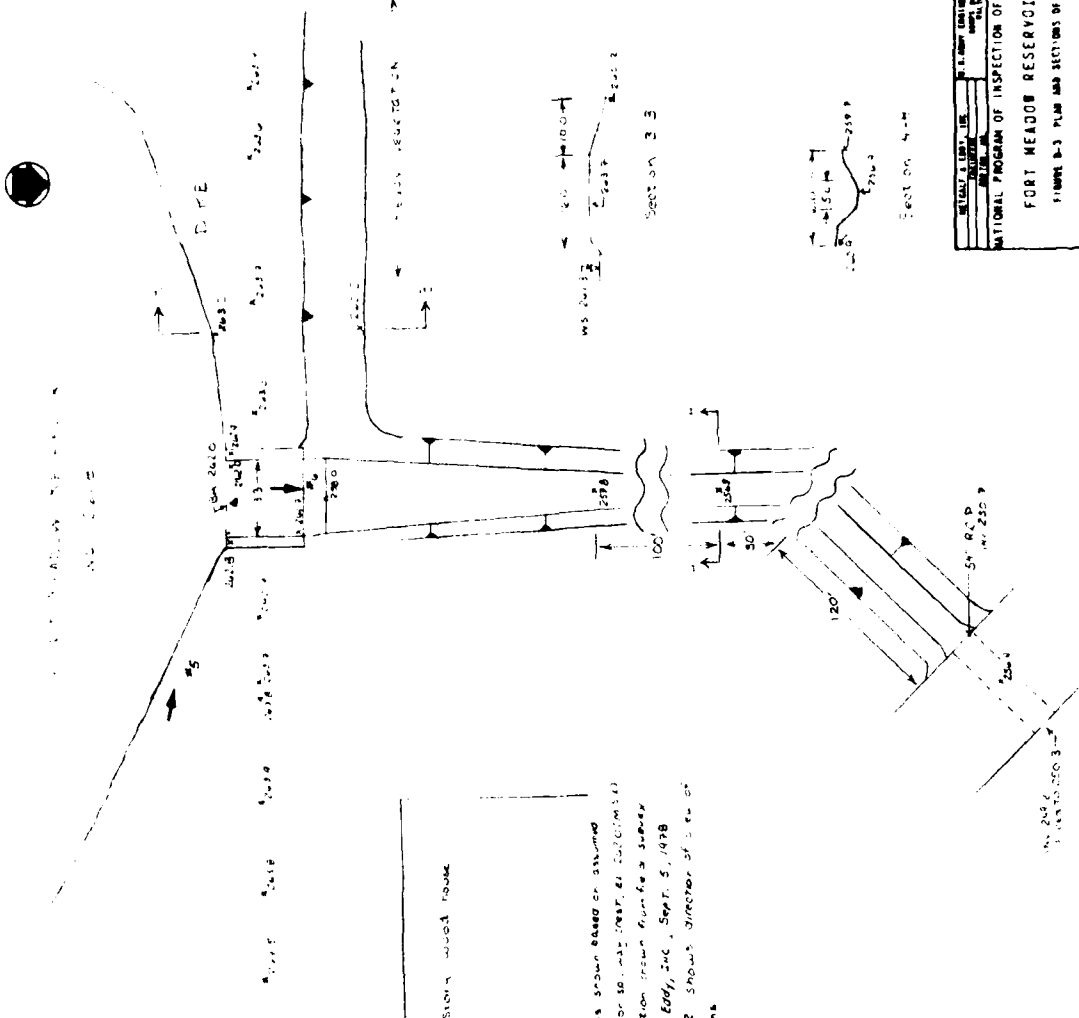
Action - See Back of Sheet Engineer - Metcalf & Eddy

TITLE

Special Remarks and Characteristics on Back of Sheet

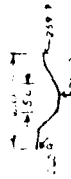
copy of a copy - original missing KE 12-2-70





- NOTES
- 1) Elevations shown based on assumed datum of 10.00 feet at 1000 feet.
 - 2) Information from plan view survey.
 - 3) METCALFE EDDY, INC., Sept. 5, 1978
 - 4) Shows direction of view of photograph.

1. SHOW MUD ROME

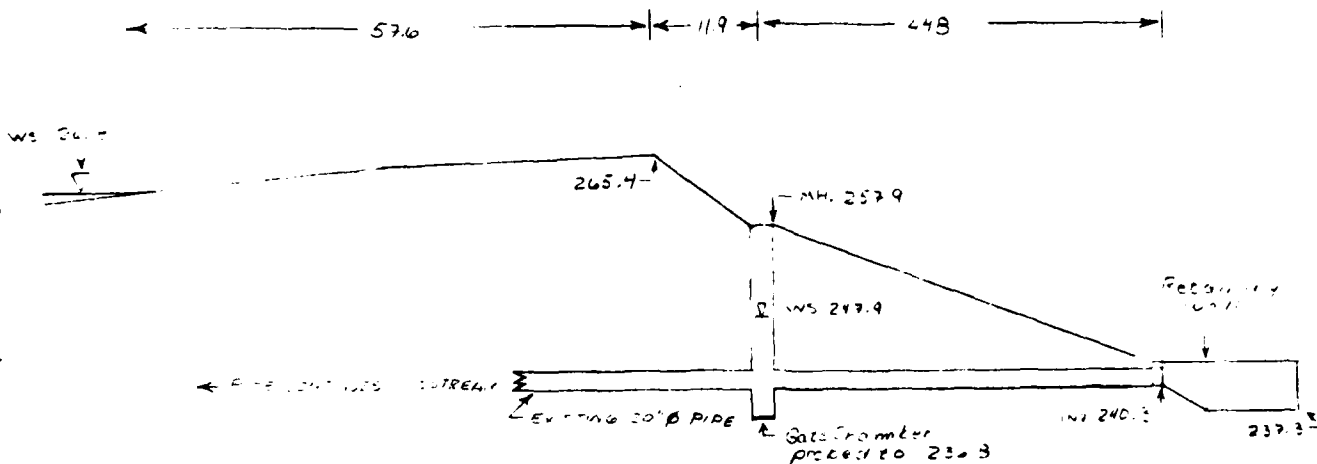


Section 3

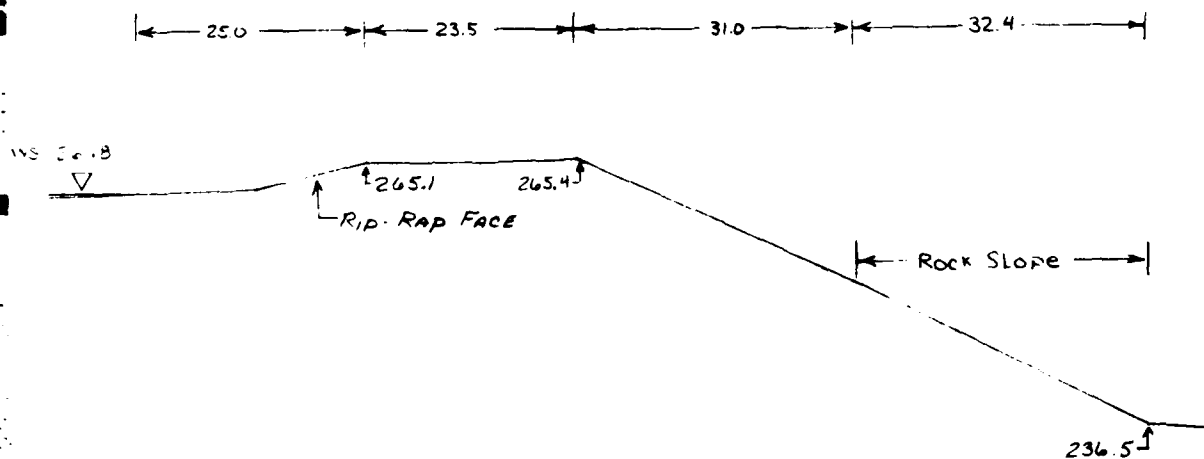
NATIONAL PROGRAM OF INSPECTION OF DAMS	
FORT MEADOR RESERVOIR DAM	
PLANS AND SECTIONS OF SPILLWAY	
TRIBUTARY ASSAULT RIVER MASSACHUSETTS	
SCALE: 1" = 20'	DATE: OCTOBER, 1978

Vertical Feet
0 20 40 60 80 100

METCALFE EDDY, INC.



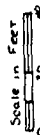
Section 1-1



Section 2-2

Scale in Feet
0 10 20

METCALF & EDDY, INC. ENGINEERS BOSTON, MA.	U.S. ARMY ENGINEER DIV. NEW ENGLAND CORPS OF ENGINEERS WALTHAM, MA.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
FORT MEADOW RESERVOIR DAM	
FIGURE B-2 SECTIONS OF DAM	
TRIBUTARY ASSABET RIVER	MASSACHUSETTS
SCALE: 1" = 20'	DATE: OCTOBER, 1978



NOTES:

- 1) Elevations shown based on assumed benchmark on Spillway crest (see Figure B-3)

E1 262.0 (MSL)

2) Information shown from field survey by Mercat & Edg, Inc, Sept 5, 1978, and Plan of Toe Drain Installation, by Mercat & Edg, Inc., May, 1983

3) ~~2~~ shows direction of view of

Photographs

USCIN * 367700 502000C D (4)

5. Discussions - of 2-3 subjects (2)

EXTENSION & DATE, IF ANY.	U.S. ARMY DEVELOPMENT DIVISION WASHINGTON, D.C.
NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS	
FORT MEADOW RESERVOIR DAM	
FIGURE 5-1 PLAN OF DAM	
TRIBUTARY ASSAULT RIVER	WASHINGTON 1773
SCALE: 1" = 50'	DATE: OCTOBER, 1970

APPENDIX B

PLANS OF DAM AND
PREVIOUS INSPECTION REPORTS

	<u>Page</u>
Figure B-1, Plan of Dam	B-1
Figure B-2, Sections of Dam	B-2
Figure B-3, Plan of Spillway	B-3
Figure B-4, Toe Drain Installation	B-4
Dam Inspection Report - Middlesex County Engineering Department, April 1963	B-5
Report by Metcalf & Eddy to Middlesex County Engineering Department, April 1963	B-6
Letters from City of Marlborough to the Middlesex County Engineering Department	B-15
Inspection Report by Massachusetts Department of Public Works, July 1973	B-17

FORT MEADOW RESERVOIR DAM

PERIODIC INSPECTION CHECK LIST

PROJECT Fort Meadow ReservoirDATE 9-5-78PROJECT FEATURE SpillwayNAME L. BranaganDISCIPLINE HydraulicsNAME E. Greco

AREA EVALUATED	CONDITION
<u>OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS</u>	
a. Approach Channel	reservoir bed - beach sand
General Condition	fair
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	12 to 18-inch trees both sides
Floor of Approach Channel	sand
b. Weir and Training Walls	8-inch concrete curb walls
General Condition of Concrete	fair to poor inlet section displaced
Rust or Staining	n/a
Spalling	some
Any Visible Reinforcing	none
Any Seepage or Efflorescence	none
Drain Holes	none
c. Discharge Channel	natural stone riprap
General Condition	poor to fair: slight seepage under slab
Loose Rock Overhanging Channel	none
Trees Overhanging Channel	many
Floor of Channel	irregular - cobbles and boulders
Other Obstructions	two footbridges; chain link fence along channel; snow fence across channel

- d. Culvert downstream of spillway under private road: ϕ 54", R.C.P.
freeboard 33" stone and concrete reinforced wall in fair condition
timber log as headwall; earth and stone channel.

Corrective Treatment

It is not within the scope of this report to recommend detailed repairs. We do however, discuss certain corrective measures which should be considered.

After the water level in the reservoir has been lowered to a point where the downstream slope is stabilized, it may be possible to effect temporary repairs. A possible temporary repair would be an extension of the outlet works and the placing of selected sizes of sands and gravels along the toe of the downstream slope to act as a filter. No work should be done on the slope of the main embankment until it has been stabilized, because any movement of embankment material could cause a failure.

For permanent repairs the "piping" should be eliminated by providing adequate drainage for the embankment. Also suitable material should be added to the downstream slope in order that the slope have a minimum grade of 2 ft. horizontal to 1 ft. vertical.

To prevent erosion of the downstream slope by the small stream a suitable heavy rock toe should be provided. In addition, the places which have been eroded should be repaired, and adequate riprap placed on the upstream slopes to prevent future erosion.

W-3

The trees and bushes should be cleared and grubbed from the embankments and the top and downstream slopes protected by suitable grass cover.

A preliminary review of the spillway requirements indicates that with an allowance made for 2 ft. of storage effect in the reservoir, a spillway of about 50 ft. long and a minimum of 2 ft. of depth would be required. This spillway would discharge about 400 cfs. In order to provide the necessary depth, the spillway embankments could be raised or else the existing spillway crest lowered.

No allowance has been made for the effect of the relief of flood flows by the low area to the south of the main embankment. Final design for the reconstruction of the dam should consider the effect of this relief "plug".

Acknowledgements

The assistance of Mr. Roger R. Hilton, Assistant Middlesex County Engineer in providing information is acknowledged with thanks.

Their report has been prepared by Mr. Charles E. Cannon, Project Engineer, with the assistance of Messrs. Gordon E. Thomas and Joseph S. Krzywicki, under the direction of the writer.

Respectfully submitted,

METCALF & EDDY

Edwin B. Cobb
Edwin B. Cobb

Registered Professional Engineer
Massachusetts License No. 617

FORT MEADOW RESERVOIR DAM

HARRY P. LOFTUS
Commissioner

RECEIVED
CITY OF MARLBOROUGH
MASSACHUSETTS

MUNICIPAL GARAGE
NEIL STREET

Office	5-0000
Street Division	5-1000
Public Works Division	5-1000
Water Division	5-0000
Engineering Division	5-0000

DEPARTMENT OF PUBLIC WORKS

November 30, 1964

County Commissioners
County of Middlesex
Court House
East Cambridge 41, Massachusetts

Gentlemen:

Referring to our letter to your office on July 22, 1964 which read as follows: As a result of the order issued by your Commission on April 26, 1963 for the repair of the dam at Fort Meadow, this work was undertaken under the supervision of Metcalf & Eddy, our Consulting Engineers and performed by the W. H. White Construction Company of Auburn, Massachusetts. We would like written approval of this work by your Commission in order that we may complete our file on this project.

To date, we have had no reply, and as we are most anxious that this file be completed, we would appreciate receiving your approval at your earliest convenience.

Very truly yours,

HARRY P. LOFTUS
Commissioner of Public Works

HPL/dms

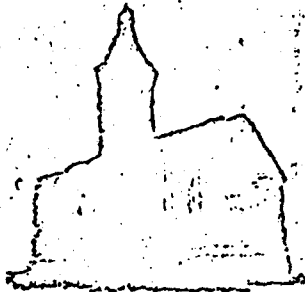
1165-0392

FORT MEADOW RESERVOIR DAM

City of Charleborough, Massachusetts

545

MAYOR'S OFFICE
KUSON J. HADDAD, Esq.
MAYOR



DONALD J. LYNCH, Esq.
SECRETARY
TEL. MU 5-0187

June 3, 1963

County Commissioners
County of Middlesex
Court House
East Cambridge 41, Mass.

Gentlemen:

Our consulting engineers, Kotalf & Eddy, have submitted to your engineers our proposed method of repairing the Fort Meadow Reservoir Dam.

Because of the orders issued by you on April 25, 1963 that we proceed with the draining of the Reservoir, we have lowered the level of the water six feet and are now ready to proceed in an emergency before our City Council and proceed with the repair of the dam.

We intend to proceed under an emergency appropriation and retain the R. H. White Company to work under the supervision of Kotalf & Eddy on a force account basis. The specifications are included in the plan submitted, and work will proceed immediately to overcome this dangerous condition.

In addition to relieving the danger involved, this is our principal summer recreation area and we are desirous of restoring the water to its original level as soon as possible.

Very truly yours,

Kuson J. Haddad
KUSON J. HADDAD
Mayor

KJH/dos

RECEIVED
1963 JUN -4 AM 9:12
MIDD.CO.COMM

INSPECTION REPORT - DAMS AND RESERVOIRS

OK 281
FILE(1.) Location: City/Town MARLBOROUGH.Dam No. 4-9-170-1.Name of Dam FORT MEADOW RESERVOIR
DAMInspected by: A. Z. PIZAN &F. H. PARE
Date of Inspection 7-25-'73(2.) Owner/s: per: Assessors ✓ Prev. Inspection _____
Reg. of Deeds _____ Pers. Contact _____

1. <u>CITY OF MARLBOROUGH, DEPT. PUBL. WKS, NEIL ST.</u>	<u>485-0392</u>
Name _____ St. & no. _____ City/Town _____ State _____ Tel. no. _____	
<u>MARLBOROUGH, MASS. - 01752</u>	
2. _____	_____
Name _____ St. & no. _____ City/Town _____ State _____ Tel. no. _____	
3. _____	_____
Name _____ St. & no. _____ City/Town _____ State _____ Tel. no. _____	

(3.) Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner,
appointed by multi owners.SAME
Name _____ St. & no. _____ City/Town _____ State _____ Tel. no. _____(4.) No. of Pictures taken NONE.

(5.) Degree of Hazard: (if dam should fail completely)*

1. Minor _____	2. Moderate <u>✓</u> _____
3. Severe _____	4. Disastrous _____

* This rating may change as land use changes (future development)

(6.) Outlet Control: Automatic _____ Manual ✓ _____
Operative ✓ yes ; _____ No.Comments: 2' DIAMETER PIPE CONTROLS OUTLET FLOW.SEE SKETCH(7.) Upstream Face of Dam: Condition:

1. Good <u>✓</u> _____	2. Minor Repairs _____
3. Major Repairs _____	4. Urgent Repairs _____

Comments: _____

-2- DAM NO. 4-9-170-1

(8) Downstream Face of Dam: Condition: 1. Good ☒ 2. Minor Repairs _____
3. Major Repairs _____ Urgent Repairs _____

Comments: _____

(9) Emergency Spillway: Condition: 1. Good ☒ 2. Minor Repairs _____
3. Major Repairs _____ 4. Urgent Repairs _____

Comments: _____

(10) Water level @ time of inspection 2 ft. above _____ below ☒
top of dam ☒ Principal spillway _____
other _____

(11) Summary of Deficiencies Noted:

Growth (Trees and Brush) on Embankment BRUSH ON EMBANKMENT
Animal Burrows and Washouts _____
Damage to slopes or top of dam _____
Cracked or Damaged Masonry _____
Evidence of Seepage _____
Evidence of Piping _____
Erosion _____
Leaks _____
Trash and/or debris impeding flow _____
Clogged or blocked spillway _____
Other _____

FORT MEADOW RESERVOIR DAM

4-9-170-1

-3-

(12) Remarks & Recommendations: (Fully Explain)

DAM IS IN GOOD CONDITION.

(13) Overall Condition:

1. Safe ☒
2. Minor repairs needed ☐
3. Conditionally safe - major repairs needed ☐
4. Unsafe ☐
5. Reservoir impoundment no longer exists (explain)
Recommend removal from inspection list ☐

FORT MEADOW RESERVOIR DAM

DESCRIPTION OF DAM
DISTRICT #4

Submitted by FRANCIS H. PARE & ADAM Z. PIZAN Dam No. 11-9-120-1
Date 7-25-73 City/Town MALBOROUGH 01752
Name of Dam FORT MEADOW RESERVOIR

1. Location: Topo Sheet No. 23 D
Provide 8 1/2" x 11" in clear copy of topo map with location of Dam clearly indicated.
2. Year built: 1848 Year/s of subsequent repairs UNKNOWN
3. Purpose of Dam: Water Supply _____, Recreational ✓,
Irrigation _____, Other CHANGED FROM RESER
4. A RECREATIONAL AREA 1952 MR LOUIS GIULINI, SUPT. OF RECREATION DEPT. MALBOROUGH MA
01752 TEL. NO. 465-7200
Drainage Area: 2 SQ. MI. 17.80 ACRES.
5. Normal Ponding Area: 300 acres; Ave. Depth 10'
impoundment: 1.61L Gals; 3,000 acre ft.
6. No. and type of dwellings located adjacent to pond or reservoir
i.e. summer homes etc. 200 PERMANENT HOMES ADJACENT TO POND
7. Dimensions of Dam: Length 320' Max. Height 30'
Slopes: Upstream Face VERT
Downstream Face "
Width across top 20'
8. Classifications of Dam by Materials:
Earth ✓, Conc. Masonary ✓, Stone Masonary ✓
Timber _____, Rockfill _____, Other _____
9. a. Description of present land usage downstream of dam: 20% rural;
80% urban
b. Is there a storage area or flood plain downstream of dam, which could accommodate the impoundment in the event of a complete dam failure
✓ YES

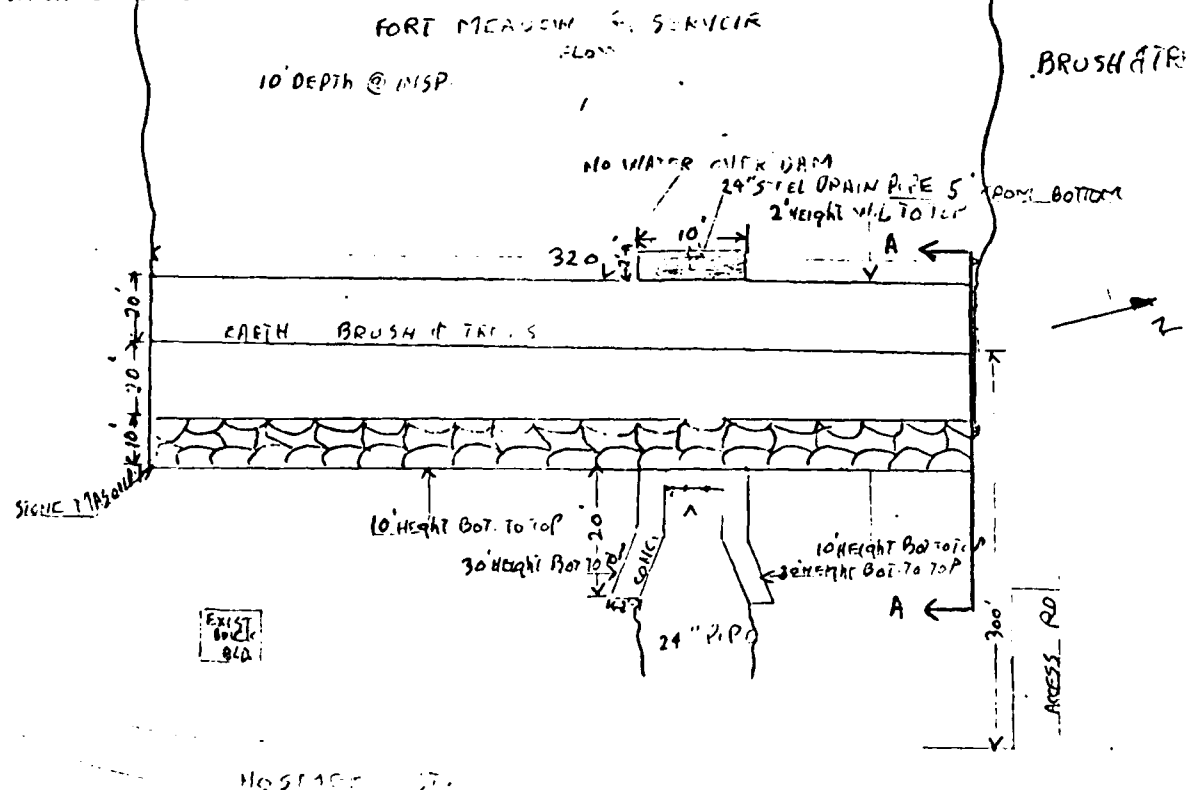
DAM NO. 4-9-170-1

10. Risk to life and property in event of complete failure.

No. of people EST. 75
No. of homes 11 25
No. of businesses NONE
No. of industries 11
No. of utilities 11
Railroads NONE
Other dams 11
Other _____

Type _____
Type _____

11. Attach sketch of dam to Form showing section and plan 8 1/2" x 11" Sheet.



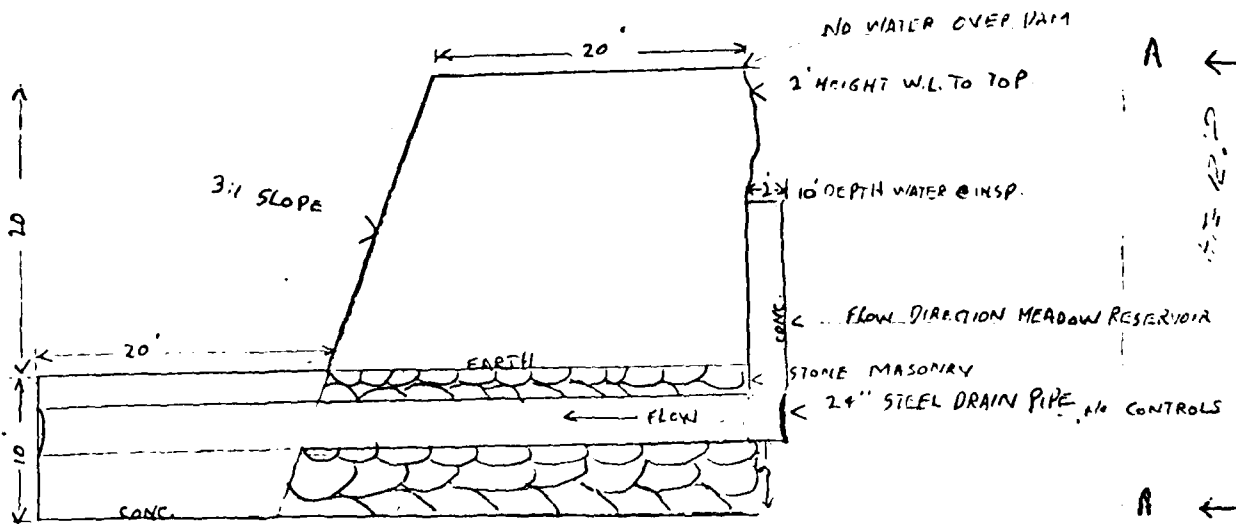
TOP VIEW

SKETCH NOT TO SCALE

FORT MEADOW RESERVOIR DAM

3

4-9-170-1



X SECTION AA
SKETCH NOT TO SCALE

FORT MEADOW RESERVOIR DAM

APPENDIX C
PHOTOGRAPHS

FORT MEADOW RESERVOIR DAM



NO. 1 SOUTH VIEW OF CREST OF DAM



NO. 2 BEACH NEAR NORTH ABUTMENT OF DAM



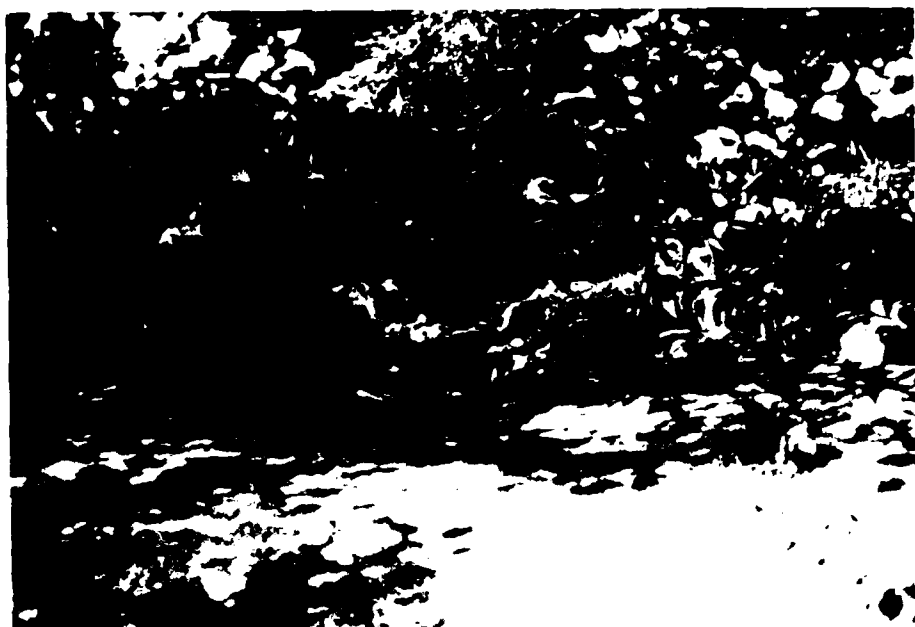
NO. 3 VIEW DOWNSTREAM OF CONDUIT OUTFALL



NO. 4 TOE DRAIN CONSTRUCTION ON
DOWNSTREAM SLOPE



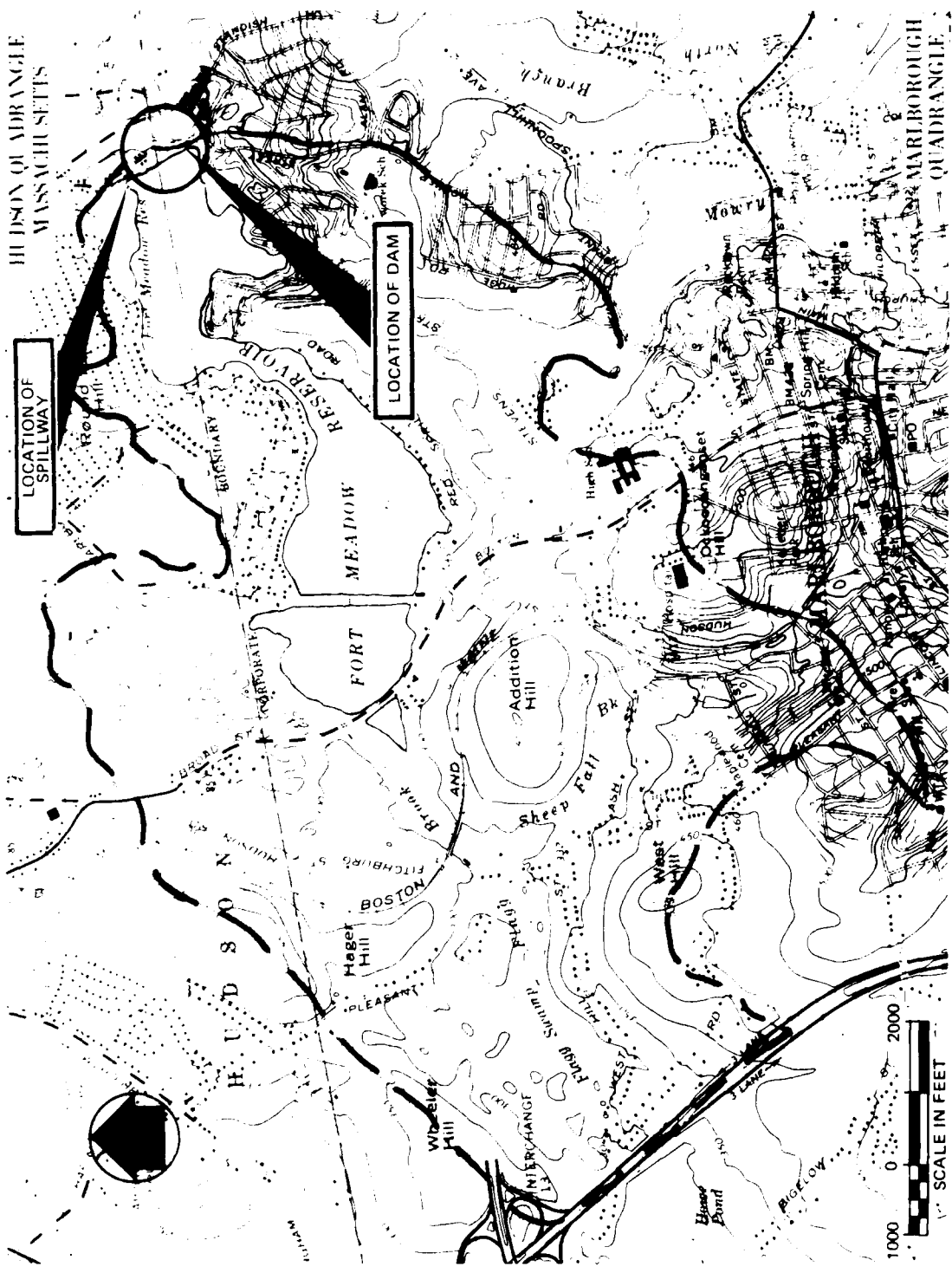
NO. 5 SPILLWAY AND DIKE



NO. 6 VIEW OF CHANNEL DOWNSTREAM
OF SPILLWAY

APPENDIX D
HYDROLOGIC AND HYDRAULIC
COMPUTATIONS

FORT MEADOW RESERVOIR DAM



LOCATION OF SPILLWAY

LOCATION OF DAM

DRAINAGE AREA MAP - FORT MEADOW RESERVOIR DAM

I Test Flood; Storage; & Storage Functions

1- Total Drainage Area - 3.44 mi²

2- Pond(s) Area: 0.41 = 0.41
 Swamp(s) Area: 0.07 + 0.03 + 0.03 = 0.13
Total Area Pond(s) & Swamp(s): 0.54

$$\underline{\% \text{Ponds \& Swamps} = \frac{0.54}{3.44} = 15\%}$$

3- $\frac{590 - 262}{10200} = 0.0321$ } Say Ave Slope = 3.5%

4- Using C of E Curves for Peak Flow Rates & above guide values the Peak Flow Rate was estimated to be between Polling and "Flatland Coastal", and taken at 1450 c.f.s./mi²
 Size Class: Interm. due to storage, Hazard Potential: High
 Use FULL P.M.F. as Test Flood

5- Test Flood Inflow = (1450) 3.44 = 5000 c.f.s.

6- Pond Storage

The pond area is 0.41 sq. mi. at elev. 262
 Based on a const. area, storage increases at 262.4 ac. feet per foot of depth increase.
 Pond area has been assumed constant as the depth increases, for the purposes of this study.
 At elev 266 the storage depth above spillway crest is 4', for a volume of 1050 acre feet.

7- Storage Functions are based on $Q_{out} = Q_{in} [1 - \frac{S_{out}}{R}]$

S_{out} = Storage Vol. in Reservoir related to final Q_{out}
 in terms of inches of rain over the drainage area

$$S(\text{in Inches}) = 12 D \left(\frac{0.41}{3.44} \right) = 1.43 D; R = 5 \text{ hr rain duration}$$

D = Storage Depth (above spillway) on reservoir, in feet

8- Storage Function: (F_{TF})

$$\underline{F_{TF} = 5000 - 263 S = 5000 - 376 D}$$

II Discharge Ratings

A- Low Level Outlet Conduit [Ref. Williams & Hager "Hydr. Tables"]

20" ϕ C.I.P.; Length - 160' \pm ; C=100; Ent+Exit Loss+Valve=1.7 h_v
 $H = \text{Head} = \text{Pond El.} - 241.3 = h_f + 1.5 h_v$; Spill. Cr. @ El. 262

For 20" ϕ w/ C=100 : $K = \frac{14.18 \text{ fps}}{(1.0448)^{.34}} = 75.855$ [Values from Max Vel for 20" ϕ in Table]

Say Vel. $\approx 20 \text{ fps}$; $k_f = (160') \frac{(20^{.15})}{K^{1.852}} 2g = 2.168$, Say 2.2 [Trial Value see below]

$$H = \frac{V^2}{2g} [1.7 + 2.2] = .06056 V^2; \text{Area } 20" \phi = 2.18 \text{ ft}^2$$

Pond El.	262	263	264
H	20.7	21.7	22.7
V	18.5	18.9	19.4
Qc	40.3	41.3	42.2
k _f	2.19	2.19	2.18 ← Close Enough to Trial Value

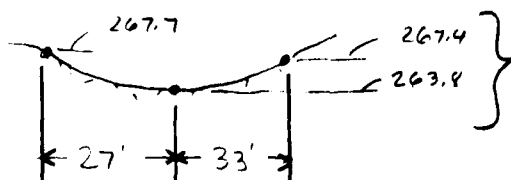
B- Spillway

[Ref V.T. Chow "Op. Chan. Hydr." pp 360-362]

$Q_s = 3.12 L H^{1.5}$ w/ L = Act Width of Weir on Spillway = 13.3'
 Crest Elev 262, $H = \text{Pond El.} - 262$, $Q_s = 41.5 H^{1.5}$

Pond El.	263	264	265	266	263.5	264.5	265.5	266.5
Q _s	42	117	216	332	76	164	272	396

C-1 Southwest Swale



Say 24' @ El 264, 15' @ El 265, 15' @ El 266

C-2 Dam Crest

From Plan: 150' @ El. 265; 130' @ El 265.3

C-3 Spillway Dike

From Plan: 40' @ 263; 110' @ 263.8

II Discharge Ratings - (Cont.)

C-4 Total Crest Flows

Use $g = 2.55(H)^{1.5}$, 150'± @ El. 265, 130'

Pond El.	40'@263	110'@263.4	24'@264	165'@265	130'@265.3	150'@266	Total
263.5	36	—	—	—	—	—	40
264	102	25	—	—	—	—	130
264.5	187	164	22	—	—	—	370
265	288	369	61	—	—	—	720
265.5	403	622	112	149	30	—	1320
266	530	915	173	421	194	—	2230
266.5	668	1244	242	773	436	14	3380

IV Summary of Results

A- Max. Crest Flow

Occurs on dike near spillway @ crest elev 263

Depth = 3.4', $g = 2.55(3.4)^{1.5} = 16.0$ cfs/ft

Where flow is critical: $y_c = 2.0'$, $V_c = 8.0$ fps

B- Low Level Outlet

$Q_c = 41.3$ cfs @ Pond El. 263. — or 12.0 c.s.m.

This is 3.3% of Test Flood Outflow

C- Time to Drain Res. 1 Foot by Low Level Outlet

$$\frac{0.41(43650)(640)}{41.3(3600)} = 76.9 \text{ hours or } 4,613 \text{ min}$$

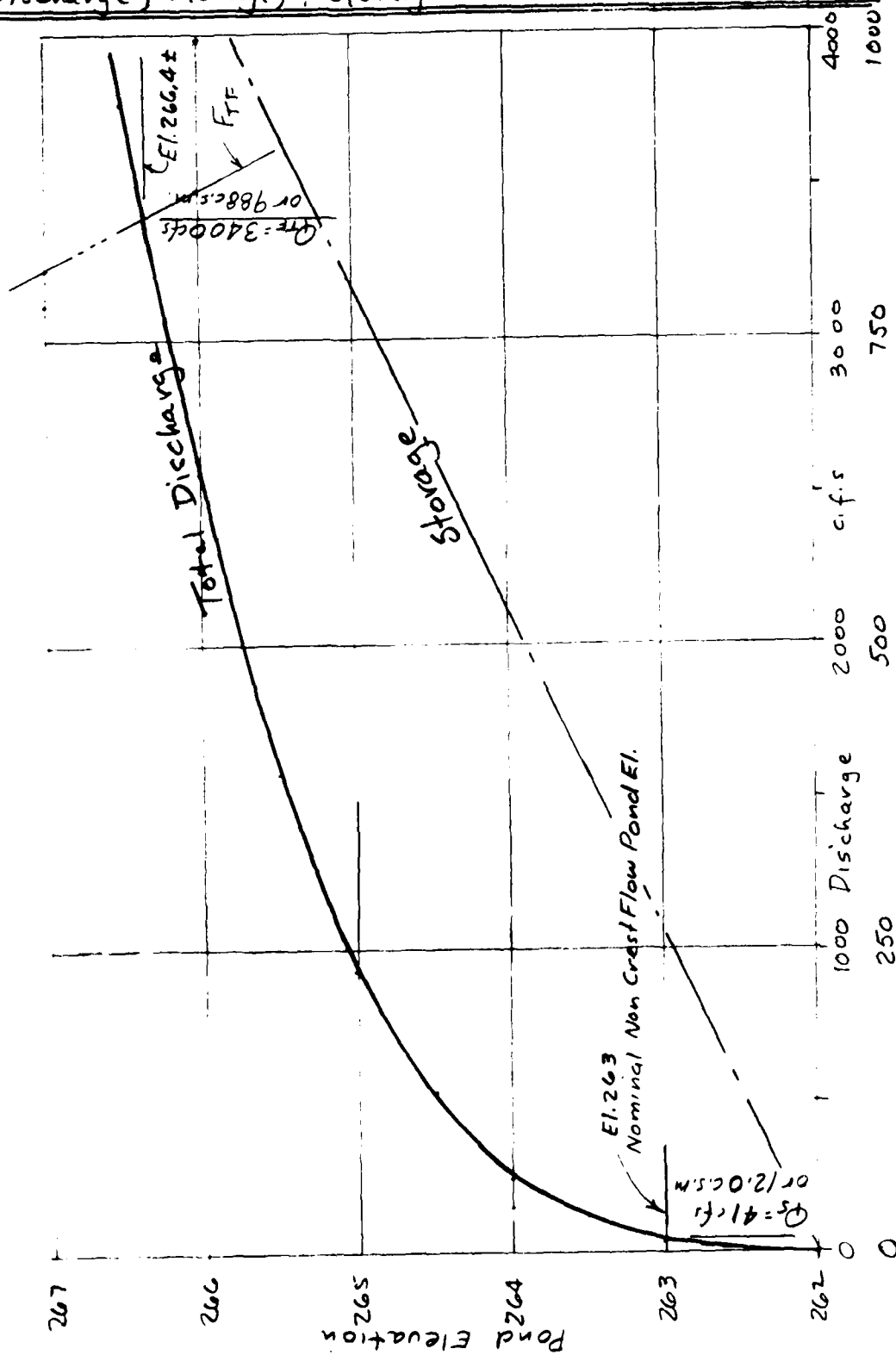
D- Max Spillway Discharge

Max. Spillway Discharge @ Pond El. 263, when crest flow is imminent = 41 c.f.s.

This is 1.2% of Max. Test Flood outflow

Project Nat. Review of Non Fed. Dams Acct No 6036 Page 4 of 6
 Subject Worcester Mass. Area Comptd By LEB Date 10/6/78
 Detail FORT MEADOW RESERVOIR DAM Ckd By F.T. Date _____

III Discharge, Storage, & Storage Function vs Pond Elevation



Project Nat Review of NonFed Dams Acct No. 5864 Page 5 of 6
 Subject Worcester Mass. Area Comptd By LEB Date 10/6/78
 Detail FORT MEADOW DAM Ch'd. By RWT Date 10/6/78

⑤ Failure of Spillway Dike (where less than 263.5±)

Peak Failure Flow:

Pond Elevation - 263

Toe Elevation - 260

$$Y_0 = 3'$$

Dam Length Subject to Breaching = 60'±

$$W_0 = 40\% (60) = 24'$$

$$Q_P = 1.68 W_0 (Y_0)^{1.5} = 1.68 (24) (3)^{1.5} = \underline{210 \text{ cfs}}$$

Storage Volume Released:

Storage Above Spillway 263

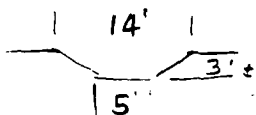
Storage Below Spillway 2187

S = Total Storage = 2450 Ac. feet

Channel Hydraulics:

$n = .08$ (Much debris & fences)

$$S = \frac{1}{100} = .01, V = 1.86 R^{2/3}$$



$$A = y(5 + 1.5y), P = 5 + 3.6y$$

y	A	P	$R^{2/3}$	V	Q
1	6.5	8.6	0.83	1.54	10
2	16	12.2	1.20	2.23	36
3	28.5	15.8	1.48	2.76	79
4	44	19.4	1.73	3.21	141
6	84	26.6	2.15	4.00	336

Outlet channel would spill over its banks less than a foot

A number of residences near the channel would be minimally affected by failure wave

Time to Drain:

$$\frac{43560 (265 \text{ ac})}{3600 (1/2) (210)} = 30.5 \text{ Hours or } 1832 \text{ min.}$$

VI Failure of Dam

Peak Failure Flow: 41 c.f.s. with pond @ el. 263± down spillway

Pond Elevation - 263

Toe Elevation - 236.5

$$Y_0 = 26.5$$

Main Dam Length Subject to Breaching = 280'

$$W_0 = 40\%(280) = 112'$$

$$Q_P = 1.68 W_0 (Y_0)^{1.5} = 1.68(112)(26.5)^{1.5} = 25700 \text{ cfs}$$

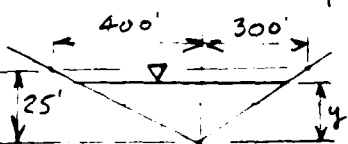
Storage Volume Released:

Storage Above Spillway: From Graph = 263

Storage Below Spillway $0.41(640) \frac{1}{3} 25 = 2187$

$S = \text{Total Storage} = 2450 \text{ acre feet.}$

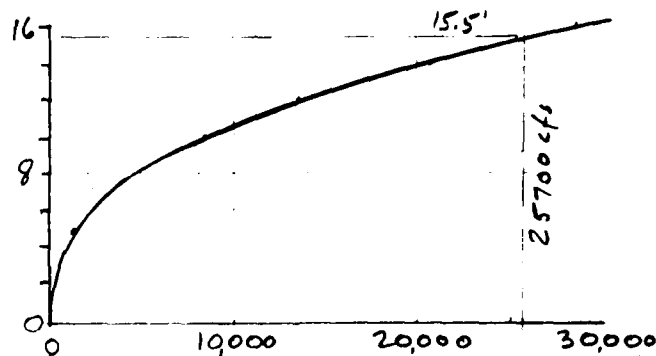
Channel Hydraulics:



$$n = 0.05, S = \frac{5}{1100} = .0045, V = 2 R^{2/3}$$

$$A = 14y^2, P \approx 28y \therefore R \approx \frac{1}{2}$$

y	A	$R^{2/3}$	V	Q
5	350	1.84	3.68	1289
10	1400	2.92	5.84	8187
12	2016	3.30	6.60	13300
14	2744	3.66	7.32	20080
16	3584	4.00	8.00	28670



Initial way would reach nearby Miles Standish Dr area with out significant diminution

Time to Drain:

$$\frac{43560 (265 \text{ ac.})}{3600 (\frac{1}{2}) (25700)} = 0.25 \text{ Hours} = 15 \text{ Minutes}^*$$

*This ignores effects of Marlboro St culvert & narrows in reservoir

APPENDIX E

INFORMATION AS CONTAINED IN THE
NATIONAL INVENTORY OF DAMS

PORT HADLOW RESERVOIR DAM

STATE	DIVISION	CONGR. STATE	CONGR. COUNTY	CONGR. DIST.	NAME	LATITUDE NORTH	LONGITUDE WEST	REPORT DATE DAY MO YR
MA	449	NED	MA	017 05	FORT MEADOW RESERVOIR DAM	4222.5	7131.9	200CT78

POPULAR NAME		NAME OF IMPOUNDMENT	
		FORT MEADOW RESERVOIR	
REGION BASIN	RIVER OR STREAM	NEAREST DOWNSTREAM CITY-TOWN-VILLAGE	DIST FROM DAM (MI.)
01 05	FORT MEADOW BROOK	HUDSON	0
POPULATION		16800	

TYPE OF DAM	YEAR COMPLETED	PURPOSES	IMPOUNDING CAPACITIES		DIST	OWN	FED	R	PRV	FED	SCS	A	VER/DATE
			MAXIMUM (ACRE-FT.)	NORMAL (ACRE-FT.)									
RECTPG	1871	R	30	30	4800	4000	N	N	N	N	N	N	40DEC78

REMARKS													

D.S. HAS LENGTH	SPILLWAY TYPE	MAXIMUM DISCHARGE (CY)	VOLUME OF DAM (CY)	POWER CAPACITY INSTALLED (KW)	PROPOSED (KW)	NAVIGATION LOCKS											
						NO.	LENGTH (FT.)	WIDTH (FT.)	DEPTH (FT.)	LENGTH (FT.)	WIDTH (FT.)	DEPTH (FT.)					
1	325 U	13	41	34000													

OWNER	ENGINEERING BY	CONSTRUCTION BY
CITY OF MARLBOROUGH	UNKNOWN	UNKNOWN

REGULATORY AGENCY	
DESIGN	OPERATION
NONE	NONE

INSPECTION BY	INSPECTION DATE DAY MO YR	AUTHORITY FOR INSPECTION
METCALF + EDDY, INC.	05SEP78	PUBLIC LAW 92-367

REMARKS	

END

FILMED

7-85

DTIC